Preparation and Analysis of Wave-Coherent Pressure Observations Made from Ccgs "F. G. Creed" During the Showex '99 Field Experiment

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LONG-TERM GOAL

The principal goal is to determine the wind input source function to the radiative transfer equation governing the waves (*e.g.* Komen *et al.*, 1994).

OBJECTIVES

1. To perform an analysis of the wave-coherent pressure data collected by the RSMAS group on CCGS "F. G. Creed" during SHOWEX. The analysis is to account for and make corrections for all known mechanisms affecting the wave and pressure measurements, and to produce from the corrected time series the wave-pressure cross spectra from which the wave-supported momentum and energy fluxes from air to sea surface are derived.

2. To compare the measured wave-supported momentum fluxes with the total air-sea momentum fluxes measured simultaneously with the wave and pressure measurements.

APPROACH

The pressure and wave elevation data were collected on a boom extending from the starboard side of CCGS "F. G. Creed". The measurements were made in parallel with water elevation and wind velocity relative to the ship, boom motion and ship motion. The entire analysis of the air pressure and Pitot-derived winds will be carried out by this project. The initial preparation and calibration of the laser wave height gauge data will be carried out in parallel by Prof. M. A. Donelan and his colleagues at RSMAS. A number of ancillary measurements (wind and water stress, air stability, etc.), measured from a mast at the bow of the ship are included in the data set from the "F. G. Creed". These will be used to relate and scale the wave-supported energy and momentum fluxes to the total air-sea fluxes at the sea surface.

The measured pressures will be corrected for at least five types of disturbance:

a) blockage of the air flow by the ship, the boom and spar supporting the pressure and (Pitot) air speed sensors and by the sensors themselves,

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14. ABSTRACT
The principal goal is to determine the wind input source function to the radiative transfer equation governing the waves (e.g. Komen et al., 1994).

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b) vertical and horizontal motion of the support structure relative to the water surface,

c) effects of water blockages of the sensing ports,

d) frequency response of the pressure sensing systems,

e) vertical acceleration of enclosed volumes within the pressure sensor system,

f) Vertical motion of the pressure sensors in the mean atmospheric pressure gradient.

WORK COMPLETED

The RSMAS pressure and directional wave measurement data set covers the SWATH vessel activity in SHOWEX: 8 Nov. – 12 Dec. 1999. Analysis of the wind input data is ongoing in collaboration with M. A. Donelan at RSMAS - present status: preprocessing of the wind input runs is 30% complete (all laser wave runs, 10% of the Elliott pressure and Pitot wind runs). At the moment mean meteorological parameters are being supplied by the BIO "dissipation" technique values of the wind stress, aerodynamic roughness, friction velocity, *et cetera;* eddy correlation air-sea fluxes measured on the "F. G. Creed" will be used when they become available. A paper on the wind input experimental apparatus on board CCGS "F. G. Creed" has been prepared for a special SHOWEX Issue of the Journal of Atmospheric and Oceanic Technology. The next step in the analysis initiative will be a month-long joint study with M. A. Donelan at RSMAS in October and November 2001. The scheduled completion of the wind input analysis is Spring 2003. The expected scientific outcome will be the JAOT paper, a JPO note + paper describing the initial results and (about 1 year later) the full results of the SHOWEX wind input measurements.

RESULTS

Preliminary results from a few "clean" runs indicate that the measurement and analysis system is capable of producing useful estimates of the wave-supported momentum and energy fluxes providing all calibrations and corrections to the laser wave height and air pressure data are performed with care. Based on a few runs, the SHOWEX wave-supported momentum and energy fluxes are physically realistic and do not disagree with earlier measurements of these quantities made in enclosed waters from fixed towers (*e. g.* Snyder *et al.*, 1981). The Figures below apply to data run 65, made on Dec. 6, 2001.

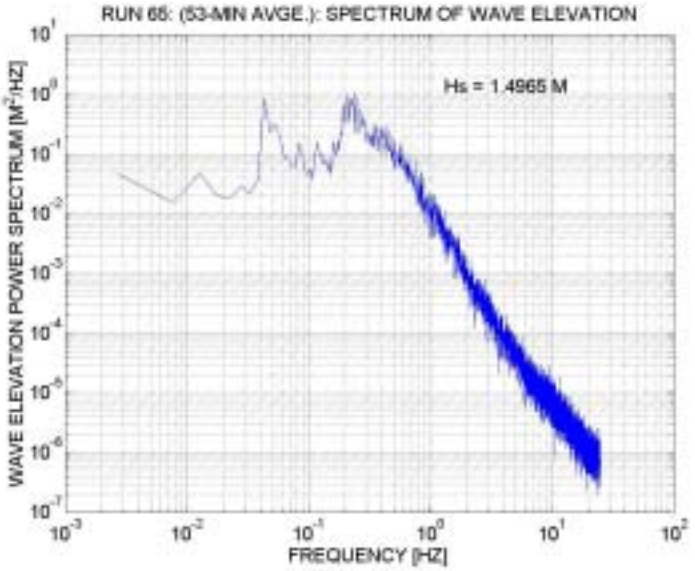

Figure i: Power spectrum of wave elevation (average of the three lasers in the "short slope" array – 10-cm. equilateral triangle). It is a "spectrum of encounter" because the Doppler-shifting of frequencies caused by the ship's speed (13 kt.) has not been allowed for. Note that there are two peaks, at encounter frequencies of 0.042 and 0.21 Hz; these translate into intrinsic frequencies of about 0.20 and 0.04 Hz. The low-frequency peak arises from waves traveling with the ship.

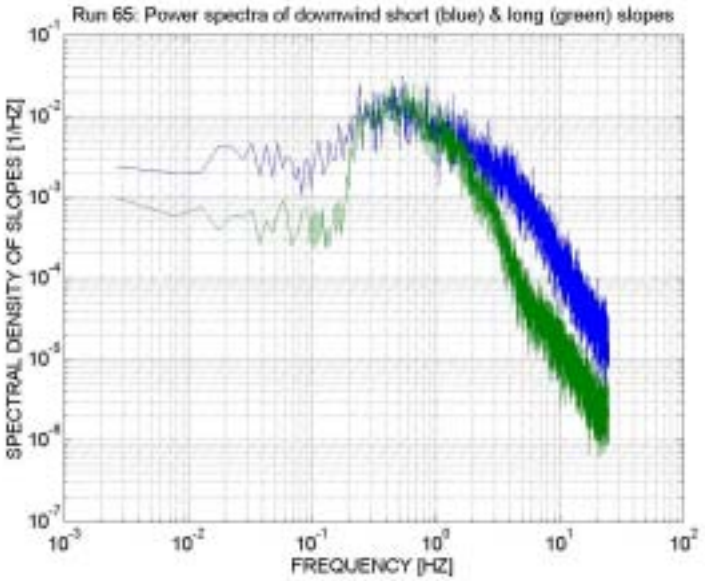

Figure ii: Power spectra of the slopes calculated by the "short" (10 cm.) and "long" (1 m) laser arrays. Note the broad peak at and above the wave spectrum peak. The spectra are forced to agree at the peak, since the short slope will have larger bias errors (short baseline).

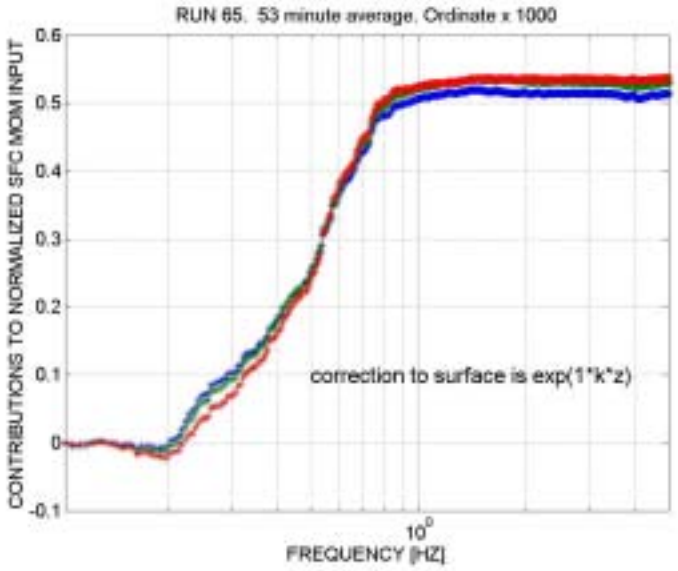

Figure iii: Cumulative sum of contributions to the wave-supported momentum flux from each spectral band of the pressure-short slope co-spectrum. The sums are scaled with the (bulk) total wind stress $\tau = \rho_\alpha (U10N)^2$, where ρ_α is air density and U10N is the 10m neutral stability wind speed, so the asymptotic values are wave-supported drag coefficients. Note that the pressure amplitudes are extrapolated to the sea surface. The argument of the exponential used for the extrapolation is within the scatter of earlier determinations (e.g. Snyder et al., 1981).

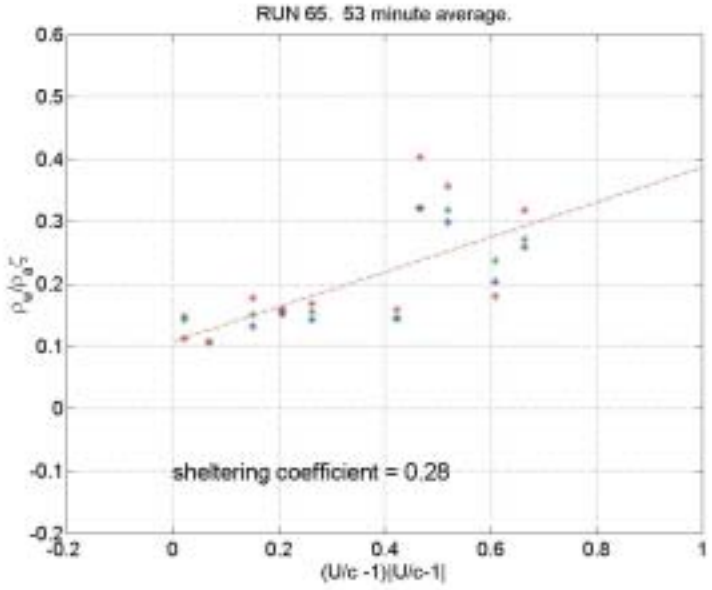

Figure iv: Dimensionless plot of rate of energy input $\zeta\rho_w/\rho_a$ where ζ is the fractional energy flux per radian to the waves from the wind and ρ_w and ρ_a are water and air densities. The abcissa is the square of the "true" inverse wave age U/c (difference from fully developed).

IMPACT/APPLICATIONS

When the wave-supported momentum fluxes are compared with the total air-sea fluxes from the SHOWEX field experiment, a new standard will be made available for modeling interchanges between the atmosphere and the sea surface wave field in a shoaling environment using the action transfer equations (*e.g.* Komen *et al.*, 1994).

TRANSITIONS

None yet.

RELATED PROJECTS

1. The SHOWEX field experiment (Grant # N00014-97-1-0348). Collaborators: H. Graber, M. Donelan, W. Drennan, RSMAS, U. Miami, F.Dobson, Bedford Institute of Oceanography.

2. Comparison of wave-supported and total fluxes measured on CCGS "F. G. Creed" with the measured values on the ASIS buoys during SHOWEX. Collaborators: H. Graber, M. Donelan, W. Drennan, RSMAS, U. Miami.

3. Comparison of wave and wind parameters with marine wave radar measurements of Normalized Radar Cross Section measured on CCGS "F.G. Creed during SHOWEX. Collaborator: J. R. Buckley, Remote Sensing Institute, Royal Military College, Kingston, ON.

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Snyder, R. L., F. W. Dobson, J. A. Elliott and R.B. Long, 1981: Array measurements of atmospheric pressure fluctuations above surface gravity waves. *J. Fluid Mech.* **102**, 1-59.

PUBLICATIONS

Donelan, M. A., F. W. Dobson, H. C. Graber, N. Madsen and C. McCormick, 2001: Measurement Of Wind Waves And Wave-Coherent Air Pressures On The Open Sea From A Moving Swath Vessel. *J. Atmos. Oc. Technol.* (submitted).